Spaceborne Radar Measurements of Vertical Rainfall Velocity: The Non-uniform Beam Filling Considerations

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Abstract

Knowledge on the global distribution of vertical velocity of precipitating particles is important in estimating latent heat fluxes, and therefore in the general study of energy transportation phenomena in atmosphere. Future spaceborne missions intend to address this issue by proposing the usage of spaceborne Doppler precipitation radars. Although the high relative speed of the instrument respect to the rainfall droplets contributes significantly to the spreading of the Doppler spectrum, accurate estimates of the average vertical velocity can be obtained when the rainfall intensity does not vary significantly within the resolution volume of the instrument. Such a result can be inferred through theoretical calculations and is confirmed by analyzing the Doppler spectra simulated using data gathered by the NASA/JPL airborne rain radar in TOGA-COARE.

As far as a downward pointing precipitation radar is concerned, a major problem affecting Doppler measurement at the nadir direction arises from the Non-Uniform Beam-Filling effect (NUBF). When significant variation in rain rate is present within the radar's field of view in the along track direction, the Doppler shift caused by the radial component of the satellite motion is weighted differently in different portions of resolution cell. The error caused of this non-uniform weighting may dominate any other contribution. Under this condition, shape, average value and width of the Doppler spectrum may not be directly correlated with the vertical velocity of the precipitating particles. However, by

using an inversion technique which over-samples the radar measurements in the along track direction, we show that the shift due to NUBF can be identified and evaluated, and that the NUBF induced errors on average fall speed can be reduced.

In this paper, the characteristics of the Doppler power spectrum under such condition will be presented, and the expected performance of some standard Doppler estimators and that of the new inversion technique will be investigated and compared.